SCIENCE

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MYCOLOGY IN RELATION TO PHYTOPATHOLOGY[1]

IN preparing a presidential address one has always to meet and answer the same old question that has confronted presidents and retiring presidents of societies ever since presidents and presidential addresses were invented, *i. e.*, Should the effort be primarily to entertain and amuse, or to instruct? I fear that any effort of mine to entertain would be a grievous failure, while an effort to instruct may be but little more successful. Since of two evils we are advised to choose the lesser, I have decided to attempt something more in the line of instruction than entertainment. Instruction is usually regarded, I believe, as a more or less normal function of a specialist, and as modern social and economic conditions have compelled specialization, we must accept the consequence.

The subject of plant pathology properly includes all the phenomena connected with abnormal forms and functions of plants. These abnormal conditions may be grouped in three classes, according to their origin: First, those which are of non-parasitic origin; second, those which are caused by plant parasites; third, those which are caused by animals. Excluding from present consideration diseases directly due to animals, we have left the two classes, non-parasitic and parasitic. By far the greater part of the trouble with which the phytopathologist has to deal are caused by plant parasites. In fact, the greater part of the phytopathology of to-day might quite properly be designated parasitology, and

[1] Address of the retiring president of the Botanical Society of Washington, March 2, 1915.

parasitology is of course only a branch of mycology.

Plant pathology is a subject of very recent development and can scarcely be said to have existed before the middle of the last century. During the period from 1830 to 1850 attention began to be given to this subject. Unger, Wiegmann, Meyen, Raspail and Regel wrote on the diseases of plants. These authors took up the subject from the standpoint of general botany and human pathology rather than mycology. Some very curious ideas prevailed; *e. g.*, it was believed that fungi such as rusts were produced by the puncture of insects (Raspail, 1846). Unger's idea was that certain fungi were outgrowths or modifications of the tissues of the diseased plant. These and earlier works contained various more or less academic discussions of various diseases, based largely upon erroneous ideas of the structure and nature of the parasite as well as the host. As an illustration of how persistent medieval ideas and conceptions are I may cite a recent instance. A correspondent, in explaining the cause of a strawberry disease, states that it is due to "elemental debasement." This reminds one of the "original sin" of the old theology, to which it may perhaps be closely akin.

Under the influence of the important contributions to the knowledge of the cellular structure and tissues of plants, which were made during this period, together with the work of contemporary mycologists, the foundation was laid for a more rational and correct interpretation of plant diseases and parasites.

Since the great majority of plant diseases are caused by fungi, it is quite proper that mycology should be considered the chief cornerstone of this branch of science and should be thoroughly understood by the plant pathologist.

In order to get a proper conception of any subject and to understand and appreciate its present condition and needs, a knowledge of its past history and development is necessary. It is quite appropriate that Florence, the chief seat of learning and the leader in literature, religion, art and science during the Renaissance and beginning of the modern era, with the illustrious names of Dante, Savonarola, Raphael and Michael Angelo should have produced the great botanist, Micheli, who may be justly considered the father of mycology. His great work, "Nova Plantarum Genera," published in 1729, was devoted largely to the description and illustration of fungi. This work remained unsurpassed for fifty years and is still recognized as a classic on this subject. Micheli's collections of fungi are still preserved in Florence beside those of Cesalpini. Some of his specimens compare favorably with those of much more recent mycologists.

Following Micheli some twenty-five years later came Battara, also an Italian. During the latter half of the eighteenth century Tode, Hoffman, Batsch, Bulliard and Persoon made important contributions to descriptive mycology. In the early part of the nineteenth century the most distinguished students of the subject were Persoon, Greville, Wallroth, Link, Sowerby, Fries and Corda in Europe, while in America the illustrious Schweinitz laid the foundations of American mycology and took rank among the first mycologists of the world. Following him in this country came Curtis, Ravenel, Peck, Ellis, Farlow and Burrill. Most of the work of the early writers was systematic, and may appear to some of us to be very crude and unsatisfactory, but when we consider the conditions under which they labored and the tools and technique available, it will be found that their work is of as high quality

as could be expected; and is perhaps no more imperfect than ours will appear to mycologists and pathologists a century hence.

Beginning about 1850, there was a great change and improvement in methods and aims in mycological work. The two most conspicuous men of this period were De Bary and Tulasne, who understood a careful comparative study of all that was known of the morphology and physiology of fungi, as well as original investigations of the life histories of the organisms. At the same time Berkeley in England, while devoting his time chiefly to descriptive work, gave much attention to the pathological aspects of the subject and published a very important series of papers in the *Gardener's Chronicle* (1854) on "Vegetable Pathology." In this connection, M. C. Cooke, who has recently passed away, should be mentioned. In America Farlow, Bessey and Burrill first introduced laboratory methods of studying fungi, taking up the work along the lines indicated by De Bary and Tulasne.

NOMENCLATURE

In considering the various phases of mycology in their relation to plant pathology, the subject of nomenclature deserves mention. The plant pathologist as well as the mycologist must use plant names. It is therefore important that this matter should be given careful consideration, in order to devise means of securing as nearly as possible uniformity and stability of usage. Unfortunately at present there is no generally accepted method of accomplishing these ends. It is therefore desirable that pathologists take an active interest in this subject and assist in determining what the fundamental requirements are to secure uniformity and stability and exercise their influence to secure the general adoption of such regulations. One of the subjects of most fundamental importance in this connection is that of types. It does not seem possible to secure any great degree of uniformity in the use of names until generic and specific names are fixed to definite types. Teachers of mycology and pathologists should consider these matters in a scientific spirit and without reference to personal preference or professional affiliations.

Closely related to this subject is that of terminology in general. There is at present a decided lack of accuracy and uniformity in the use of the various technical terms used in mycology and pathology. With the exception of the rusts, the descriptive terms used have not been accurately defined and coordinated in accordance with our present knowledge; *e. g.*, the term conidium is variously applied to spores produced either on external sporophores or within pycnidia. There is also lack of general agreement and uniformity in regard to the names applied to the various conidial and pycnidial forms of the Ascomycetes. We have such terms as stylospore, spermatium, micro- and macro-pycnospore, micro- and macro-conidium variously applied by different writers.

Of great importance also to the pathologist is the standardizing of methods and technique as far as possible. Though absolute standards in these matters can not well be attained, effort should be made to approximate definite standards as closely as possible.

TAXONOMY

Mycology formerly consisted chiefly of the identification of old species and the describing of so-called new species. This of course was natural and necessary, as there was a vast unknown group of organisms most of which had not been named or described. Unfortunately, the overwhelm-

ing number of the species and the few workers made it impossible for them to devote the time and study to the organisms necessary for satisfactory segregation and description. Species were usually based upon supposed host relations, slight morphological differences or geographical distribution. More recent and thorough studies have shown that these can not be generally depended upon. While one species of a genus may have very definite host relations, the next one may be very indefinite in this respect. In the same way morphological characters which are reliable in one genus or species may be very variable and unreliable in another. The same may be said of geographical distribution. Some species are apparently more or less cosmopolitan, while others are confined to rather limited geographical areas. These facts can only be determined by the most thorough monographic study of each genus or group. Our studies of *Endothia* have brought out these points with great clearness and emphasis. For instance, one of our American species, *E. gyrosa,* extends from the Atlantic coast to the Pacific, and from Connecticut and Michigan to Florida and Texas, whereas its near relative, *E. radicalis,* is restricted to the Appalachian region in America. Such facts are of exceeding importance to the pathologist in determining the nature and possibilities of a parasite.

LIFE HISTORIES

Of still greater importance to pathology, however, is a knowledge of the life histories of parasites. This subject is not only of exceeding importance to pathology, but also to phylogeny and taxonomy in general, and has important bearings on all other branches of mycology. The work of Tulasne and De Bary and their contemporaries was the first important contribution to this subject. Following the discovery of the pleomorphy of the Ascomycetes there was a tendency on the part of some mycologists to connect up all the various known forms of the so-called Fungi Imperfecti upon the basis of association, similarity or other more or less uncertain evidence. One of the most striking cases of this is furnished by Fuckel in his "Symbolæ Mycologicæ," 1869, where supposed pycnidial or conidial forms are given for the majority of the Ascomycetes listed. In some cases the author was probably correct, but none can be accepted without being verified by cultural studies or other reliable methods. The work of Tulasne, while much more reliable and satisfactory, was based primarily upon the intimate association or union in the same stroma of the different forms of fructification. Much of his work has already been verified by later investigators. Brefeld in his great work on the life histories of the fungi made an exceedingly important contribution to this subject. Unfortunately, many of the conidial and pycnidial forms which he obtained in culture from ascospores can not be identified and connected with certainty with forms already described.

It has already been thoroughly demonstrated that some of the Pyrenomycetes have from one to three metagenetic spore forms besides ascospores; *e. g., Sphærella, Glomerella, Guignardia, Plowrightia,* etc. It is also well known that some of the stages of a fungus may be parasitic and others apparently saprophytic; *e. g.,* many Pyrenomycetes mature their perithecia upon dead vegetable matter, while their pycnidial or conidial forms may be actively parasitic. This has led to the classification of most of the Pyrenomycetes, whose life histories are not known, as saprophytes. It is clear, therefore, that to even be able to classify an organism satisfactorily as a

parasite or saprophyte its life history must be known.

Here is a vast field for investigation which offers great opportunities for making valuable contributions to knowledge. Thousands of pleomorphic species whose life histories are unknown await the patient and properly equipped investigator. Present culture methods must be improved and new methods probably devised in order to induce many of these fungi to pass through their complete life cycles. It is in this field that we may expect very important discoveries in regard to the factors which determine the production of any particular spore form in the life cycle of a fungus. Of such factors we have very little definite knowledge at present.

PARASITISM

The exact nature of parasitism, its origin and modifications, is naturally of the utmost significance to pathology. This problem can perhaps be attacked with the greatest promise of successful solution in those cases which appear to be near the border line between saprophytic and the parasitic species. If we admit that evolutionary processes are still active, there seems no reason to doubt that parasites are at present in process of evolution. Whether this evolution is brought about by mutation or by a gradual accumulation of slight variations or by some other process or complex of processes not yet discovered, it would seem possible to get further light on this subject by a thorough investigation and comparison of some of the active parasitic Ascomycetes and their near relatives which seem to be saprophytic or only very weakly parasitic. A striking example of this condition of affairs is presented by the genus *Endothia* already referred to. *Endothia parasitica* is a most virulent parasite, whereas its near relative, *E. radicalis*, which occurs on the same host, shows little or no parasitic tendencies, while some of the other species show slight indications of parasitism.

ECOLOGY

In this connection it may be well to call attention to the great possibilities in the study of the ecology of the fungi. At present, unfortunately, there is little exact knowledge of the distribution and environmental relations of fungi. The exact limits of distribution of but very few species is known, and in fact the exact identity of many species is still doubtful. The question of their host relations is also not well understood except in the case of the rusts, smuts and powdery mildews. Our studies of *Endothia* appear to indicate that, in this group at least, the species have very definite geographical ranges which are not determined by their host relations, but apparently are very intimately associated with climatic and other environmental conditions, as well as competition with other fungi. All these things are of vital interest to the pathologist, especially in connection with the possibilities in the way of the spread of any particular parasite, or in determining the probable behavior of any foreign species which might be introduced. To know what fungi exist in any region and what their natural distribution and host relations are, is of the utmost importance in devising ways and means to prevent their introduction into other countries. In this connection I may quote from Winthrop Sargent in the Final Report of the Pennsylvania Chestnut Tree Blight Commission, 1914, page 12, as he presents the case in a very plain and forceful manner:

> In conclusion, it seems necessary to call sharp attention to the real lesson to be learned from the chestnut blight epidemic—viz.: the necessity of more scientific research upon problems of this

character; to be undertaken early enough to be of some value in comprehending, if not controlling the situation. We have seen that the blight might have been kept out of the country in the first place by inspection, or, once in, that it might have been destroyed, or at least checked, before it had gotten widely distributed. But instead it was permitted to enter, and to spread for many years without scientific notice, and for several more years without any organized attempt to control it, or even to study it seriously. Are we doing any better now with reference to the future?

GENETICS

While perhaps not having the same direct bearing upon pathological problems, still it may be worth pointing out that fungi appear to offer one of the simplest and easiest points of attack on the general problems of evolution, such as mutation, variation, and inheritance; in fact, the various problems of genetics. Here we have organisms comparatively simple in structure, either asexual or at least not complicated by possible hybridization and capable of rapid reproduction and cultivation under controlled conditions.

Coming finally to questions of prevention and control of diseases caused by parasites, it is only stating a truism to say that whatever success may be attained in this direction must depend chiefly upon the completeness of our knowledge of the parasite in all its aspects and relations.

Finally, mycologists, pathologists and all real scientists are searchers after truth. This implies not only large opportunities, but also obligations. "Noblesse oblige" is particularly applicable to the scientist. In these days of storm and stress it is, if possible, more important than ever that we should live up to the highest ideals of truth, and make individual and united effort to establish the universal reign of justice, peace, and brotherly love among mankind.

An excellent example of what the scientist should strive to be in all his human relations has been given us by Professor Charles E. Bessey, the distinguished botanist and beloved teacher, whom death has so lately taken from us. He not only sought truth and taught truth, but lived it, making the world not only wiser and richer, but better. May we all leave as noble a record when called to lay life's burdens down.

C. L. Shear

EDWARD WESTON'S INVENTIONS

The pioneer work of Dr. Edward Weston is not easy to describe in a few words. His restless inventive activity has been spread over so many subjects, has intertwined so many interlocking problems, that in order to understand its full value, it would be necessary to enter into the intimate study of the various obstacles which opposed themselves to the development of several leading industries which he helped to create: the electro-deposition of metals, the electrolytic refining of copper, the construction of electric generators and motors, the electric illumination by arc- and by incandescent-light, and the manufacture of electrical measuring instruments. An impressive list of subjects, but in every one of these branches of industry, Weston was a leader, and it was only after he had shown the way in an unmistakable manner, that the art was able to make further progress and develop to its present-day magnitude.

But why was Weston able to overcome difficulties which seemed almost unsurmountable to his predecessors and coworkers in the art?

The answer is simple: He introduced in most of his physical problems a chemical point of view—a chemical point of view of his own; a point of view which was not satisfied with general statements, but which went to the bottom of things. He did not